REMARKS

This application contains claims 1-19 and 21-33. Claims 1, 3 and 23 are hereby amended, while claims 2 and 4 are canceled. No new matter has been introduced. Reconsideration is respectfully requested.

Applicant gratefully acknowledges the interview held by Examiner Hassanzadeh with applicant's representative, Daniel Kligler (Reg. No. 41,120), at the U.S. Patent and Trademark Office on January 30, 2003. The substance of the interview is contained in the Interview Summary prepared by the Examiner.

The drawings were objected to for absence or improper use of certain reference numbers. Proposed amendments to the drawings, in the form of Figs. 3, 4 and 5A (formerly Fig. 5) are attached hereto in order to correct certain of these errors, while the specification has been amended to correct others. Upon the Examiner's approval of the proposed amendments to the drawings, corrected drawings in compliance with 37 CFR 1.85 will be filed as a separate paper with a transmittal letter addressed to the Official Draftsperson.

Fig. 3 has been corrected to substitute the reference numbers 70 and 85, which are mentioned in the specification, for numbers 100 and 105, which are not mentioned. Fig. 4 has been corrected to reverse the positions of lines 130 and 135, so as to accord with the positions of these lines in Fig. 5A. Furthermore, reference number 95 has been added in both Figs. 4 and Fig. 5A, as suggested by the Examiner. Reference number 140 has been removed from Fig. 5A. The specification has been amended to mention vapor inlet 130 (Figs. 4 and 5A); graph 150 and arrows 155 and 160 (Fig. 6); and radiation guide 200 (Fig. 7, rather than in Fig. 6 as indicated by the Examiner).

As suggested in the interview, applicant submits herewith a new Fig. 5B, showing a system combining the cleaning module of the original Fig. 5 with a particle detection unit 145, as claimed in amended claim 1. (The original Fig. 5 has now been renumbered as Fig. 5A, as noted above.) As explained at the interview, such a system is already disclosed in the text of the specification as filed (page 12, lines 10-14 and 25-27), and therefore does not constitute new matter.

In the above-mentioned Official Action of September 11, 2002, the Examiner indicated that claims 19 and 20 were withdrawn from consideration as being drawn to a nonelected species. Applicant respectfully points out, however, that only claim 20 is drawn to

the nonelected species (species 2). The species of claim 19 (species 1) was elected for further prosecution in applicant's Preliminary Amendment and Response, submitted July 16, 2002. (An amendment to claim 19 was included with this response.) Therefore, the Examiner is requested to cancel his withdrawal of claim 19 and to examine this claim in the next substantive action.

Claims 1-18 and 21-33 were rejected under 35 U.S.C. 103(a) over Maekawa (EP-0,764,478-A1) in view of Engelsberg et al. (U.S. 5,531,857) and, with respect to some of the claims, further in view of Vaught (U.S. 5,023,424) or Allen (U.S. 4,987,286). Maekawa describes a method and apparatus for cleaning a semiconductor substrate, using a swing arm to move a rotatable cleaning unit over the substrate (col. 5, lines 1-8). The cleaning unit includes a cleaning member, which is used, for example, to scrub the surface of the substrate while a nozzle ejects a cleaning liquid onto the surface (col. 5, lines 24-29, and col. 6, lines 2-4). Engelsberg, Allen and Vaught all describe methods and apparatus for removing contaminants from a surface using high-intensity radiation. Vaught, in addition, describes the use of a particle position detector to locate the position of particles on a wafer (col. 3, lines 55-57). After detection of the particles in a particle detector station, the wafer is transported to a particle removal station for cleaning (col. 3, lines 47-50).

Applicant has amended claim 1 in order to more clearly distinguish the present invention over the cited art. Amended claim 1 incorporates certain limitations of claims 2 and 4 (now canceled), as well as additional aspects of the present invention that are described in the specification. The claim now recites an arrangement wherein a chuck is used to position a substrate within a processing chamber for scanning by a particle localization unit. The same chuck, in the same chamber, is used to position the substrate with respect to an optical arm so that a beam of energy is directed by the arm to impinge on particle locations determined by the localization unit. Claim 3, which previously depended from claim 2, has been amended to depend from claim 1 with correct antecedence.

The additional features recited by amended claim 1 are literally supported by the specification of the present patent application. As noted on page 12, lines 12-14, the optical arm of the present invention may be incorporated in an existing metrology tool, making use of a rotating chuck or X-Y stage that is already present in the system. An embodiment of this sort is now shown in Fig. 5B, and is described on page 12, lines 15-27. It

is noted specifically (lines 19-20) that the optical arm in this case may be either rotatable or fixed and (lines 25-27) that this configuration is useful in the context of particle detection tools, which commonly include an X-Y stage already. A method for performing inspection using this sort of particle removal unit simultaneously with a particle location process, as recited in amended claim 1, is described on page 17, lines 1-19.

The novel combination of amended claim 1 is neither disclosed nor suggested by the prior art. Although Vaught describes the use of a particle detector in conjunction with a laser-based particle removal station, these two elements are clearly separate units, as noted above. (See also Vaught's Fig. 1 and col. 6, lines 31-38.) Because of the size of particle removal systems known in the art at the time of filing of the present patent application, it was not practical to combine particle detection and radiation-based removal of contaminants in a single chamber. Even if the particle detection and particle removal systems could somehow have been housed together in a single chamber, contaminants and process gases generated by the particle removal process would have been likely to foul the optics of the particle detection system.

These shortcomings of the prior art are overcome by the novel optical arm of the present invention, which both is sufficiently compact to mount in the same chamber as the particle localization unit and is configured to contain and remove contaminants and process gases. The invention recited by amended claim 1 is advantageous in terms of conserving space in the semiconductor fab and reducing the time required to process each substrate. These advantages are enumerated in the above-mentioned passages of the specification of the present patent application, as well as on page 7, lines 9-25. Although Engelsberg and Maekawa mention the use of "arms" in applying cleaning processes, neither of them makes any suggestion that such arms could be used in a directed, localized process, as required by claim 1.

Thus, applicant respectfully submits that claim 1, as amended, is patentable over the cited art. In view of the patentability of claim 1, claims 3, 5-19, 21 and 22, which depend from claim 1, are believed to be patentable, as well.

Applicant respectfully traverses the rejection of claims 23-33. Claim 23 is an independent claim, which recites a cluster tool for processing a semiconductor wafer. The cluster tool comprises a processing chamber for forming features on the wafer; a particle

removal unit, which uses a beam of electromagnetic energy to dislodge contaminants from the wafer; and a wafer transfer mechanism, which transfers the wafer between the processing chamber and the particle removal unit. This embodiment of the present invention is shown in Fig. 8 and is described with reference thereto. Claim 23 has been amended to correct a minor error in antecedence.

In rejecting claim 23 (over Maekawa in view of Engelsberg) in the present Official Action, the Examiner did not specifically relate to the features of the claim. Neither Maekawa nor Engelsberg teaches or suggests incorporating a particle removal unit in a cluster tool, which also includes a processing chamber for forming features on the wafer and an air-tight wafer transfer mechanism, as required by claim 23. This novel combination is also not disclosed or suggested in any of the other cited references. It has advantages of compactness and enhancing process speed and yield, as described in the specification on page 7, lines 9-25.

Thus, applicant respectfully submits that claim 23 is patentable over the cited art. In view of the patentability of claim 23, claims 24-33, which depend from claim 23, are believed to be patentable, as well.

Applicant has studied the additional prior art cited by the Examiner, and believes that the claims currently pending in the present patent application are patentable over this additional prior art, as well, whether taken alone or in combination with other references.

Applicant believes the amendments and remarks presented hereinabove to be fully responsive to all of the grounds of rejection and objections raised by the examiner. In view of these amendments and remarks, applicant respectfully submits that all of the claims in the present application are in order for allowance. Notice to this effect is hereby requested.

Respectfully submitted,

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Version With Markings To Show Changes Made

Amendments to the Specification:

Paragraph at page 8, line 20, has been amended as follows:

Fig. 5A is a schematic, sectional view of a cleaning module for removal of particles from a substrate during a manufacturing process, in accordance with a preferred embodiment of the present invention;

Paragraph at page 12, line 1, has been amended as follows:

Fig. 4 is a schematic, sectional view of cleaning module 10, showing further details of its construction, in accordance with a preferred embodiment of the present invention. Substrate 30 is preferably held on chuck 25 by a suction mechanism 125. Preferably, a coolant channel 120 conveys a coolant 122, such as water, to chuck 25 in order to cool substrate 30, and thus to prevent thermal damage. Arm 40 conveys laser beam 75 to impinge on substrate 30, and also comprises a vapor inlet 130. Suction channel 95 is connected to a suction gas outlet 135. Rotation of chuck 25 is controlled by a motor 140. Although module 10 is shown here as an independent unit, in an alternative embodiment of the preferred embodiment, arm 40 is incorporated in an existing process chamber or metrology tool and makes use of a rotating chuck or X-Y stage that is already present in the system.

Paragraph at page 12, line 15, has been amended as follows:

Fig. 5A is a schematic, sectional view of cleaning module 20, in accordance with another preferred embodiment of the present invention. In this embodiment, wafer 30 is mounted on an x-y stage or platform 111. Cleaning arm 40 may rotate about the ϕ axis, or it may be fixed, since the x-y stage allows the laser beam to reach all areas of the wafer surface without the necessity of scanning the laser beam, as well. The configuration of Fig. 5A is useful in the context of particle detection tools, which commonly include an x-y stage already. A system combining the cleaning module of Fig. 5A with a particle detection unit 145 is shown in Fig. 5B.

Paragraph at page 12, line 28, has been amended as follows:

Fig. 6 is a graph 150 showing a water absorption spectrum as a function of the wavelength of the incident radiation, useful in understanding aspects of the present invention. In order to achieve high absorption of the laser beam in a water film deposited on wafer 30, wavelengths of 10.6 μm and 2.95 μm are preferred, as they are points of strong absorption. The 2.95 μm absorption, indicated in the figure by an arrow 155, is more than one order of magnitude stronger than absorption at 10.6 μm, indicated in the figure by an arrow 160. Preferably, laser module 60 is designed to generate a tuned, pulsed laser beam at wavelengths that are tailored according to the particular particle removal application, including both vapor-assisted and dry methods. Different process stages and contaminant types typically require different methods and different wavelengths for optimal cleaning. Thus, module 60 is preferably able to generate both ultraviolet and infrared (IR) radiation, which is most preferably tunable to the water absorption peak at 2.95 μm.

Paragraph at page 13, line 13, has been amended as follows:

Fig. 7 is a simplified block diagram illustrating elements of multi-wavelength laser module 60, constructed and operative in accordance with a preferred embodiment of the present invention. A Nd:YAG laser source 170 emits a laser beam at 1.06 μm, which is directed into an optical parametric oscillator (OPO) 180. The OPO down-converts the laser frequency so as to emit a beam in the mid-IR, at one of the wavelengths at which water has an absorption peak, as shown in Fig. 6. Alternatively, a pulsed CO_2 laser (10.6 μm wavelength) can be used instead of the OPO. Beam shaping optics 190 direct the IR beam into a radiation guide [50] 200, which then carries the beam to arm 40. Preferably, module 60 also includes an ultraviolet (UV) laser, such as a Lambda Physik (Gottingen, Germany) LPX315 IMC excimer laser. The UV laser is highly efficient for cleaning bare silicon, while OPO 180 can generate radiation in the strong absorption region of water (2.95 μm) such that "explosive evaporation" conditions are reached and efficient particle cleaning achieved when UV cleaning is ineffective or unsatisfactory for other reasons. Alternatively, an Er:YAG laser may be employed.

Amendments to the Claims:

Claims 1, 3 and 23 have been amended as follows:

1. (Amended) Apparatus for removing particles from the surface of a substrate, comprising:

a moving chuck, which is configured to receive the substrate and to move the substrate within a processing chamber;

a particle localization unit, which is adapted to scan the surface as the substrate is moved by the chuck in the processing chamber, in order to determine locations of particles on the surface; and

an optical arm, which is adapted to direct a beam of electromagnetic energy onto the surface of the substrate while the substrate is mounted on the chuck within the processing chamber, causing the particles to be dislodged from the surface, [the arm being movable, in cooperation with the movement of the chuck, in order to scan the beam over the surface]

wherein the chuck is operative to position the substrate relative to the optical arm so as to cause the beam to impinge upon [substantially any point] the locations of the particles on the surface [from which the particles are to be removed] that are determined by the particle localization unit.

3. (Amended) Apparatus according to claim [2] 1, wherein the optical arm is adapted to rotate about a base thereof so as to scan the beam according to the particle [position coordinates] locations.

23. (Amended) A cluster tool for processing a semiconductor wafer, comprising:

a processing chamber, adapted to receive the wafer and comprising apparatus for forming microcircuit features on the wafer;

a particle removal unit, adapted to receive the wafer and comprising an optical assembly for directing a beam of electromagnetic energy onto a surface of the wafer so as to dislodge contaminants from the surface; and

a wafer transfer mechanism, coupled to transfer the wafer between the processing chamber and the particle removal [station] <u>unit</u> substantially without exposing the wafer to ambient air.